GOVERNMENT OF PORTO RICO

BOARD OF COMMISSIONERS OF AGRICULTURE

RIO PIEDRAS, P. R.

FIFTH REPORT

OF THE

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OF

PORTO RICO

6th Report of the Insular Experiment Station.

FOR THE PERIOD FROM

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SAN JUAN, P. R.

BUREAU OF SUPPLIES, PRINTING, AND TRANSPORTATION

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REPORT OF THE PATHOLOGIST.

[By JOHN A. STEVENSON.]

INTRODUCTION.

The work in plant pathology and botany has been continued substantially along lines indicated in the report for the year 1914–15, although there have been certain modifications of projects therein outlined due to unforseen exigencies. While much has been accomplished in the way of a plant-disease survey of the Island, with special attention to the diseases of citrus and various vegetables, equal progress has not been made in the very necessary laboratory studies of the fungi concerned. It is expected, however, that work on the most pressing of these problems will be gotten under way during the coming year since additional assistance will be available. In the case of some of the serious plant diseases measures for control are and will continue to be entirely empirical until the obscure points in the life histories of the causal organisms can be worked out in the laboratory.

WORK OF THE YEAR.

Considerable time (approximately 75 days) has been given to field studies in various citrus groves, pineapple plantations, and in certain disease-infected cane fields; in the course of which work extensive collections have been taken, observations made on the various diseases, their prevalence, hosts, etc., and the effect of any control measures that had been instituted. This has been in large part essentially extension work with an effort to disseminate such information as was available among the planters and to render such assistance toward the solving of their many problems as was possible.

Somewhat more time was given to field studies at the Station, including observations on vegetable diseases, spraying experiments for their control and similar studies with cane, citrus, and the other economic and ornamental plants grown on the grounds. The balance of the time available has been given to the proper care and arrangement of the flowering plants and fungi collected during the year (1,500 numbers) and to laboratory studies of the more serious plant

diseases. Preliminary cultures have been made and a basis laid for further detailed work on the life histories of these latter forms.

An exhibit of the more important citrus diseases of Porto Rico was prepared and placed at the office of the Porto Rico Fruit Exchange at a time when frequent meetings of the growers were being held. A specimen of the citrus canker obtained from the north formed part of the collection as well as a number of charts and photographs illustrating the disease more fully and setting forth its dangerous possibilities. This exhibit was later transferred to the San Juan office of the Board of Commissioners of Agriculture where it will be maintained as a permanent feature. Additional specimens of the important diseases of other economic crops are being added from time to time as they become available.

A small experimental planting of grapefruit has been made to be used in the work with the various citrus diseases. For the trees we are indebted to Mr. Mills of the Southern Cross Plantation. For fungicides, gas tar, fruit used in laboratory studies, etc., we are indebted to various firms of San Juan and to the fruit growers in general.

PUBLICATIONS.

Because of the preliminary nature of the studies of the year no publications in the regular series except the annual report have been issued. However a considerable number of press bulletins and field reports have been prepared and published in the various newspapers of the Island, both in Spanish and English, a list of which follows:

"Cause of Citrus canker." August 25.
"Experiment station notes." September 10.
"Sobre una enfermedad de la caña." September 22.
"Citrus scab and its control." December 15.
"New publication on shipping Citrus fruits." January 5.
"Citrus scab on sweet oranges." January 5.
"Melanose in Porto Rico." January 5.
"Pruning in Citrus groves." February 1.
"The Citrus canker fight." March 23.
"Pink disease of Citrus." March 23.
"A new work on Citrus culture." March 23.
"Citrus fruit rots." March 23.
"Informe sobre la enfermedad de la caña en Cambalache." April 1.
"Biblioteca Agrícola." April 10.
"An enemy of Citrus insects." April 10.

"Informe sobre la enfermedad de la caña en Camuy." April 17.
"Why cucumbers fail." May 2.

The report on cane disease in the Arecibo district has been published in both the San Juan and Arecibo papers, in "La Revista Azucarera" and in pamphlet form by the sugar company concerned.

HERBARIUM.

Very satisfactory progress has been made in the building up of the Station herbarium, both by the addition of specimens collected in the course of the work of the department and by accessions from other sources. The natural history survey of the Island conducted by the New York Academy of Science in co-operation with the Insular Government has yielded a number of specimens of flowering plants and many more are promised. As in past years we are indebted to Dr. Britton and members of the staff of the New York Botanical Garden for determinations of flowering plants and of certain groups of the fungi. Other groups of this latter class of plants have been worked up by other specialists. Determinations from these sources combined with those made in the department have given an excellent foundation for securing an adequate representation of the Porto Rican flora.

About eleven hundred sheets have been inserted in the herbarium during the year, many of them with two or more specimens each so that approximately 1,500 named specimens have been added. A very large number of collections remain to be named and mounted. One steel case has been added and there is pressing need for at least one additional. Tropical conditions including excessive humidity and an over abundance of destructive insects make anything but air tight steel cases useless. In connection with the dried plants of the herbarium proper there is being gathered together a collection of the edible fruits of the Island properly preserved, which are on display along with similar exhibits of the diseases of economic plants.

As heretofore the herbarium has made possible the making of many determinations not only in the plant disease work but for other members of the staff, and for other scientists or agriculturists who have visited the Station or sent in material for this purpose.

LIBRARY.

Satisfactory progress has been made with the library. Although funds for the purchase of new items have been limited, a very large number of accessions have been made through the medium of exchange with the Station publications, a method which will be carried

out to the fullest extent. A particular effort has been made to obtain the agricultural publications of other Latin-American countries and of tropical regions in general. Duplicates, which are received in considerable numbers from some sources are being arranged in order that they may be used for exchange. It is the aim to build up a representative agriculture library which may be used not only by members of the staff, but by residents of the Island in the study and advancement of tropical agriculture.

More detailed notes upon the plant diseases studied during the year are appended. To facilitate reference these will be divided into the main divisions of citrus, cane and miscellaneous diseases and notes. The various vegetable diseases studied will be treated in a forthcoming number of the "Journal of Agriculture."

CITRUS DISEASES.

INTRODUCTION.

In studying the diseases of citrus in Porto Rico it speedily becomes apparent that they are much the same as those reported for Florida. That this should be the case seems reasonable when it is remembered that the bulk of the groves of Porto Rico originated directly or indirectly from budwood brought from that state. There is as might be expected an even greater similarity to conditions existing in Cuba, since the Cuban industry is but an offshoot of that of Florida, and the soils and climate of the two islands are much alike. For instance, certain diseases exist in the two places which are of very minor importance or nonexistent on the mainland. While there is this resemblance in many particulars, Porto Rico is fortunate in others, in that due to its isolation it has escaped some of the diseases such as Florida scaly-bark and above all canker. It is hoped that freedom from these and especially from the latter will be maintained through the workings of the strict quarantine now in force. Inspections started in the year previous and continued in this have failed to reveal any signs of citrus canker. Special attention has been given to citrus material brought in from Florida in the period preceding the establishment of the quarantine.

During the year weather conditions have played a very striking part in the prevalence and virulence of certain of the more serious diseases as will be noted in the specific notes to follow. Taking the groves of the Island as a whole, there is an apparent gradual spread and increase of virulence of the principal fungus diseases. Moreover, a number of troubles heretofore not reported for Porto Rico, some of which at least have latent possibilities of trouble for the industry, have been found.

Increased plantings making for large continuous areas and the increasing age of established groves tend to favor the increase and spread of injurious fungi. Control measures as a result are becoming increasingly important, and what has been a much neglected phase of grove practice is being made the subject of considerable study on the part of the growers. Methods of value in other regions

fail to give results under Porto Rican conditions, and much study and experimentation will be necessary to bring about a satisfactory solution of the many disease problems.

In some groves in certain sections there is an apparent decadence of the trees setting in, and this in groves not yet fifteen years old. This problem presents for its solving even more difficulties than that of disease control, involving as it does soil conditions, environmental influences, adaptability of varieties, etc. Work will be done along this line in connection with field studies of the various fungus diseases.

Notes or data gathered during the year are here appended.

NOTES ON SPECIFIC DISEASES.

ROOT DISEASES.

This general term is here used to permit the recording of notes on the loss of trees through the death of their roots from several causes, none of which are as yet sufficiently differentiated to be treated separately.

Several cases were observed where death of trees was obviously due to standing water around the roots. In one instance the water table was within two feet of the surface. Young trees progressed favorably in such situations for a number of years until the roots began to reach down below the water level. From this time on they became unthrifty as evidenced by yellowing of leaves and dying back of twigs and branches. Death came suddenly, the final wilting and drying out of the bark often occurring within a few days, as a result of girdling at the crown by a fungus which had worked up along one or more of the main roots. This fungus (*Ustilina vulgaris*) is very common on dead wood, fence posts, etc., and has been considered merely as a saprophyte. In the present instance it had apparently acted as a wound parasite, gaining entrance through the lower ends of roots killed by water. The fruiting or reproductive bodies were produced around the crown, a black carbonous crust like layer pitted with the innumerable openings into the spore sacks. The fungus produced a characteristic dry white rot of the wood.

No indications were found of other fungi, *Rosellinia*, *Sphaerostilbe*, *Fomes*, *Armillaria*, etc., which have been held responsible for root rot of citrus in other regions. In somewhat similar cases another fungus (*Valsa* sp.) was found on exposed roots and crowns of dead and dying trees. It is more common as a dead-wood fungus and undoubtedly has only been able to attack as did the *Ustilina*,

by working in through roots killed by standing water. At least no cases have been found where there was not some other initial cause.

There have been, however, instances where trees have died without any cause being apparent, a gradual but persistent dying back over a period of several years. Examination of roots and tops failed to reveal any fungi or other causes such as standing water. The trees were in a light sandy soil and had been properly cared for. The Florida blight was suspected, but no certain symptoms of this disease appeared, and the fact that roots were rotted, or at least dead, made it still more doubtful. The removal of dead and dying trees was recommended, using care to take out the roots as completely as possible. A ditch well outside of infected trees was also advised in certain instances because of the tendency of the disease to attack an additional circle of trees each year. In the first type of root trouble proper drainage, of course, would be a sure method of prevention, the fungi present in such cases attacking only when other causes have weakened the trees seriously or made actual wounds.

FOOT ROT, MAL-DI-GOMMA.

The discoveries of Fawcett in California that certain fungi are directly concerned in gummosis and in some cases of foot rot have reopened the question of the cause of this disease. However, no indications of the fungi reported by him as causes, have been found here nor has it been possible to produce the disease on old grapefruit trees on lemon roots, the combination considered most susceptible. This disease should become increasingly less important since the usual corrective measures of drainage, removal of soil from crown and main roots and the cutting out of all diseased bark give satisfactory results, if properly carried out. The failures have for the most part been due to the fact that the laborers have not gone to the trouble of digging away the dirt from around the base of the tree and cutting out diseased bark on the roots and portion of the crown so uncovered.

PSOROSIS, SCALY-BARK.

This disease was first noted during the past season, though it has been present according to various growers for some years. It was practically confined to the orange, and for this reason was of less importance than it might otherwise have been, because of the great decrease in orange acreage of the past few years. Unless the growing of oranges is resumed, the disease will not become of any great importance.

This disease must not be confused with the scaly-bark of Florida which, while resembling it in some respects, is a very distinct malady due to a definite fungus cause. The cause of psorosis, which is the better term for the Porto Rican disease, is at present unknown.

Psorosis attacked the trunk, branches, and in several cases the small twigs. The first signs were the breaking of the outer bark into scales over areas small at first, but later many inches in diameter. There was some gumming. New bark, much thicker and rougher than normal formed over the diseased areas, followed often by further scaling away, so that there was a succession of apparent healing and renewed breaking out. From year to year the areas spread up and down infected branches, spread from one branch to another, encircled the trunk and ultimately brought death. In the early stages the outer bark only was affected, but with increase in size of the areas the bark died completely and finally even the wood beneath was killed. No fungus has been found which could be considered as in any way the cause of psorosis. *Corticium salmonicolor* and *Nectria ephisphaeria* have been found on such areas, but were certainly not causative.

Only one remedy is known. The cutting out of all diseased bark and of the wood beneath, if it is dead, followed by an application of bordeaux paste. Except in the very early stages scraping off of the loose scales and outer layers of bark will be ineffective. Seriously diseased limbs should be completely removed and in case the main trunk is also badly cankered prompt removal of the entire tree is advised. All diseased material should be burned or buried deeply. Wounds made in the course of the work should after a few weeks, be covered with a good dressing, such as tar, carbolinium, white lead, or other similar substance. If a search is made through the grove at least once a year for signs of the disease and followed up by prompt treatment, no losses should result because of its very slow progress.

GUMMOSIS.

This disease is not satisfactorily differentiated from psorosis, the symtoms being much the same. As at present considered it is confined to grapefruit and psorosis to orange, but it may appear that the two are merely manifestations of the same malady on different hosts.

Gummosis attacked for the most part the trunk and larger branches, rarely and in severe cases only, spreading to the twigs. Scaly, ulcerated areas, generally accompanied by a copious gum flow

were produced. The portions killed, becoming hard and filled with gum, were finally pushed off by new tissues forming below. Finally however, the bark died through to the wood and this in turn was killed inward for a considerable distance. Branches of all sizes were girdled and killed and it was not uncommon for cankers to occur on the trunk of such size as to destroy the tree itself. The pycnidia of *Diplodia* sp. were very commonly present in and about the cankered areas, but their exact relationship to the disease has not yet been worked out.

Control measures would be the same as given for psorosis.

PINK DISEASE (*Corticium salmonicolor*).*

This disease was first encountered during the excessive wet weather of the late fall of 1915 in several districts and has been noted with considerable frequency since that time. In some cases it was found as a follower of psorosis, acting as a wound parasite, but for the most part, however, it has acted independently as a true parasite. Both the sweet orange and grapefruit have been attacked but no other hosts have been found. This appears strange since this fungus has been reported from other parts of the tropical world as a serious disease at times of rubber (*Hevea brasiliensis*), cacao (*Theobroma cacoa*), gandul (*Cajanus indicus*), coffee (*Coffea arabica*), mango (*Mangifera indica*), and a wide range of other economic plants many of which are grown in Porto Rico. In particular the gandul or pigeon pea so widely planted in citrus groves has so far been uniformly free of this disease.

Pink disease has not become epidemic, having been limited in so far as observed to one or a few limbs only of scattering trees in any one grove. Trees in low or very sheltered places appeared more subject to it. Limbs of varying sizes were attacked but in no case was the trunk found diseased. Infection quite often occurred at the base of a limb and spread rapidly from that point reaching a length of several feet before girdling and death took place. A soft rot of the bark with a rather characteristic odor resulted. The wood beneath was also attacked and became dead and discolored. Dead wood and bark were quickly invaded by various boring insects. The fungus fruited over the surface of the bark, forming a very thin, delicate continuous layer, white at first, and then a bright salmon pink with a white advancing margin. The layer of fungal tissue spread over the healthy bark somewhat in advance of the rot. At maturity it

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* The determinations of this fungus and others of the same group have been made by Dr. E. A. Burt, of the Missouri Botanical Garden, St. Louis, Missouri.

was broken up into numerous very small, rather irregular rectangular pieces, giving a characteristic appearance to the fungus. The color after a time faded to a dull gray. At this stage it was sometimes confused with another similar fungus, *Peniophora cinerea* which was, however, a dead-wood form only, never attacking living bark.

A practical and very effective method of control was had in the cutting out and burning of diseased limbs. Such a course must be followed by proper treatment of any wounds made, to prevent re-infection.

WOOD ROT.

A fruitful source of future trouble is present in a majority of the groves; a disease which now passes unnoticed by the growers or is ignored as of no importance but which will within a few years prove an important factor in grove decadence. This is wood decay and it follows careless pruning, or any injury to the tree which is not properly treated. The fungi producing the decay are several and various types of rot are produced, in some cases of the sap wood only, in others of the heart wood, occasionally of both. However, all are similar in the one respect that an opening in the bark, or in other words a wound, is required before they can gain a foot hold, hence the term wound parasites. Having once entered the trunk or limb of a citrus tree the rot progresses slowly but none the less surely until ultimately wind or other agency breaks off the weakened tree or branch. It is the increasing prevalence of such disease that will permit the hurricane winds to reap a rich harvest in seasons to come. After a long period of growth fruiting bodies of the fungi concerned are produced on any exposed area. These are generally shelf-like with gills or minute pores borne on the under surface. *Schizophyllum commune, Coriolus* spp., *Daldinia concentrica* and others have been collected in such situations.

A remedy is not practicable. For while tree surgery (cutting out of rotted wood) would be feasible, it would not be profitable, even if skilled workmen could be found, which is doubtful. The solution of the problem lies in prevention. Under this head are included careful pruning which means clean, smooth cuts, without projecting stubs, and the treatment of wounds due to animals, mechanical injuries and diseases such as psorosis. Special precautions should be taken when cutting back for rebudding. Much of the disappointment resulting from this line of work is due to wood rot which has worked in through improperly protected cut surfaces.

DIE BACK.

This characteristic disease prevalent on the mainland occurs to a limited extent only in Porto Rico. Only in one instance in a block of orange trees was it found at all serious. It was in that case the apparent cause of the death of several trees. It was quite usual to find trees which possibly constituted light cases in that they produced multiple buds, showed some dead twigs and even had the gumming of fruit considered a positive symptom. However, it was seldom that all these symptoms were found combined in one tree and not even then was there any great loss. Die back need not be a source of worry at present. The cause is not known nor is there any certain remedy although avoidance of organic nitrogen in the fertilizers is supposed to be effective.

DIPLODIA DIE BACK.

Much of the so-called withertip and die back of twigs and small branches generally attributed to *Colletotrichum gloeosporioides*, the anthracnose fungus, is in reality due to *Diplodia natalensis*. This fungus when all phases of its activity are considered easily takes first place as a citrus enemy. Scab in certain groves or even in certain districts may cause a greater loss of fruit but when the Island is considered as a whole, the loss from rotted fruits and die-back with the resulting weak trees far outweighs that to be charged to the scab organism.

There is not a grove on the Island that does not suffer from *Diplodia* fruit rot and there is but little difficulty in finding in every case the accompanying blight of twigs and branches. In most instances normal, actively growing tissues are immune but so many circumstances can and do occur under Porto Rican conditions to impair the vitality of a tree or to break the protective bark layers that the fungus seldom lacks an opportunity of entrance. Trees subjected to periods of drouth and so checked in their growth, those growing in heavy, poorly drained soils, those improperly fertilized and in fact these weakened by any cause, are all attacked by *Diplodia*. Individual limbs become diseased when weakened by scale or by the burden of a heavy crop of fruit. The use of props seems to particularly favor the entrance of the fungus apparently because of the shutting off of the sap. At any rate it is very noticeable that in such instances the fruit is most apt to drop prematurely with stem end rot and the branch to die back for a considerable distance. Wounds of any description of course furnish ideal points of entry if not treated immediately.

Diplodia in attacking twigs and branches causes a die back in outward respects not distinguishable from that due to other causes. Careful inspection, however, presents some distinctive points. In many instances there is a production of gum, very clearly an attempt on the part of the tree, as pointed out by Earle and Rogers *, to stop the progress of the disease. Where the gum is present the advance of the disease is usually checked, a well marked line appearing between diseased and healthy wood. If it fails to develop, the dying back continues until entire limbs are killed. The presence of gum, the line of demarcation, or the fairly rapid progress of the infection down to the very trunk of the tree separate this disease from withertip, die back, or related troubles. An even more marked characteristic is the presence of the *Diplodia* fruiting bodies which occur in the greatest abundance over diseased areas as minute black hemispherical bodies, superficial, or erumpent from the bark. These have been found on dead twigs and branches, on trunk cankers, on dying roots, on rotted fruits and in connection with foot rot cases, illustrating the wide range of the fungus.

Spraying as a remedial measure will prove valueless. Recourse must be had first to a pruning out and burning of all diseased parts followed by proper precautions in covering the wounds with an antiseptic. This step, however, is but preliminary and would not serve to prevent reinfection. It will be necessary to correct the conditions that have weakened the tree and made infection possible. Measures of this nature are correct fertilization, mulching to overcome drouth, thinning the fruit, and in general any cultural methods that tend to produce healthy, normal trees. The complete removal of trees in advanced stages, in which leaves and fruit have practically all been dropped and a large percentage of the twigs and branches affected, is advocated. Time and effort spent on such trees would be wasted.

SCAB.

Possibly the most outstanding point with regard to this malignant disease of citrus has been its dependence upon weather conditions. In December (1915) when heavy rains were occurring it was feared that serious loss threatened and an article dealing with the nature of the disease and its treatment was prepared and published* in the hope that the growers, with a definite warning before them, would take some steps at least toward control. However, dry weather pre-

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* First Annual Report of the San Pedro Citrus Pathological Laboratory.
* Porto Rico Progress, Vol. IX, No. 24, December 15, 1915.

vailed during the first blooming period in February and March, with the result that the grapefruit came through in splendid shape as far as regards infection by scab. Exceptions, of course, occurred in the case of blocks of trees in low or heavily protected situations and in case of those individual trees, of which most groves have one or more, that for some reason are peculiarly susceptible to the disease.

In so far as observed any and all sprayings, no matter of what material or when or how applied, were without beneficial results. The slight traces of scab observed appeared on sprayed and unsprayed fruit to equal degree. As a whole, less than one per cent of the fruit was scabbed and most of this not so seriously as to prevent its sale.

With the advent of rainy weather in late April and May, a second heavy bloom came on and the resulting fruit was most severely attacked. A very large amount fell soon after setting, and of the remainder from fifty to ninety per cent, in those groves subject to scab, was so distorted and disfigured by scab as to be valueless. Spraying, which for the most part had been with sulphur compounds, was without apparent effect. In many cases the solutions used, while effective against rust mite, were much too weak to even hope for results against scab. One grove was noted where bordeaux had been used several times and at what was approximately the critical period, and yet infection was most serious. As far as known the Florida spraying schedule recommended in the notice published in December was not tried by any of the growers. This consists of one or more applications of bordeaux as circumstances make advisable at the time of blooming, followed by two or more of lime-sulphur. Such a system permits the application of a strong fungicide at the critical period and yet by the use of the sulphur prevents in some part, at least, the trouble from scale that invariably follows where copper sprays are used alone.

Spraying experiments carried on in cooperation with various of the growers have not proven satisfactory, due to various uncontrollable circumstances. Plans are being formulated to carry the work to more definite conclusions in the season to come. In so far as results were obtained it appears that lime-sulphur gives only slight protection from scab, not over twenty per cent, while bordeaux, if applied at the right time, will give from seventy to ninety per cent. As is well known the use of bordeaux results in a disastrous increase of scale insects which may well cause more loss than the scab. The copper salts also have an injurious effect on citrus trees independent

of the question of scale increase, in contrast to that of lime-sulphur, which is distinctly beneficial.

Some observations have been made upon the value of cutting out twigs bearing scabbed leaves and removing diseased fruit, a course often recommended as a step in control. It does not seem probable that efforts of this nature will bring the desired result or at least sufficient results to recompense the grower for the added expense and trouble. No matter in what quantities or how thoroughly scabbed material may be removed reinfection occurs in a propitious season and with undimished intensity. Other conditions not favoring, new growth remains clean in spite of the presence of an abundance of scabby leaves or fruit. One particular instance may be noted in which a grower completely defoliated one hundred large grapefruit trees by means of a severe pruning. In addition, the trunks and larger limbs were washed with strong kerosene emulsion. In the following spring a fine flush of new growth was put out, but it was soon as severely infected with scab as other portions of the same grove which had not been so treated.

There is one possible exception to the conclusion that cutting out is of no avail, a method, however, which has probably not been tried out. In most groves where the scab has not taken complete possession there are certain isolated trees, often not more than one or two, which are peculiarly most susceptible to the disease. It has been the common experience that where the malady has finally spread throughout a block of trees, its presence was known for some years previous to that time on just such trees as these. It would be an experiment well worth trying to work over all such trees as soon as found, provided other adjacent blocks or groves were free of the disease. Buds from nearby trees which did not show scab should be used.

Scab was for the first time in Porto Rico found attacking the sweet orange. In this instance sour orange trees seriously diseased adjoined them. While it is never safe to make predictions on the course a disease will take, it will not be surprising if a strain of the scab organism capable of causing damage to the orange developes. Such a course took place during recent years in the case of the grapefruit, which was formerly immune, as the sweet orange is for the most part to-day. The grapefruit strain is apparently not capable of infecting the lemon, since lemon trees have been noted in several situations, alongside of, or adjacent to, grapefruit trees which were bearing scabbed fruit and leaves. The conclusion that a sepa-

rate strain of the organism attacks each different host and does not pass except at rare intervals to others seems warranted, though not yet borne out by conclusive innoculation tests.

Because of the rather uniformly poor results from spraying other solutions of the problem have been looked for. The indefiniteness of the seasons with the possibility that heavy blooms may occur at any time or at several times from November to June, and the certainty that scattering new growth and bloom will be found at all times make spraying uncertain even provided a satisfactory substance could be found and all growers understood perfectly just how and when it should be applied. During some years the number of applications necessary to protect even the bulk of the fruit throughout the season would involve a cost out of proportion to any benefits received.

With the subject of strains of the causative organism in mind, it has been suggested that a possible course of action lies in hunting for a strain of grapefruit as it were, or a variety that is immune to the disease. As is well known the Triumph and other types have this property now, but are not of enough commercial value to make their growing advisable. Attempts must be made to select such a type from the Duncan or Marsh Seedless. Such trees are readily found in all groves, but the question of whether the apparent immunity would be transmitted through the buds when growing under other conditions would need careful attention. Care must be taken to avoid selecting weak trees or those suffering from other diseases, since such are for some reason free of scab. Even if what appears to be an immune type can be found, a series of years will be necessary to test it out.

No evidence has been found that would indicate that scab is due to any other cause than an organism commonly referred to *Cladosporium citri*. The exact position and nature of this organism remains to be worked out. As other workers have noted, it is most distinctly not a *Cladosporium*.

MELANOSE.

This disease, one of the more serious of the Florida troubles, has been frequently reported from Porto Rico, but there is no doubt but that such reports have been erroneous or have confused true melanose with the so-called black melanose or greasy spot, which is of common enough occurrence. Prof. Stevens, Pathologist of the Florida Experiment Station, advises that specimens previously examined from Porto Rico were not melanose, or at best were very

doubtful. In several localities, however, in the past few months, specimens bearing the closest possible resemblance to descriptions of melanose have been found. Markings on the fruit in one case were especially characteristic. The determination in this case was verified by Prof. Floyd, of the Florida Experiment Station, an authority on this disease.

Melanose has been found on the leaves and fruit only of grapefruit. It is characterized by numerous very small (seldom over one-thirty-second of an inch in diameter) raised areas, brown in color or at times nearly black, often described as having the appearance of masses of melted sugar burned. These are of corky tissue and entirely superficial. Their arrangement in lines or circles, as so commonly noted in other regions, has not been observed here. The markings on the fruit resemble those on the leaves, with the additional characteristic that the epiderm breaks in a ring around the raised area. Examination of twigs both in this laboratory and by Prof. Stevens has failed to reveal the presence of *Phomopsis citri*, considered the cause of the markings, nor have cultures made from any of the many rotted fruits examined proven to be of this fungus.

In those cases where the disease has been found, the grove owners have been advised to carry out a radical pruning in the infected trees, as there is always the possibility that the trouble may become epidemic. However, in view of Fawcett's observations* on the apparent preference of the disease for northern Florida rather than more southern regions, it seems unlikely that trouble will ever ensue.

BLACK MELANOSE, GREASY SPOT.

This exceedingly common spotting of the leaves is usually known as melanose among the growers and for that reason has been confused with the true melanose. It is characterized by numerous somewhat irregular areas, occurring for the most part on the under side of the leaf, and varying from an eighth to a quarter of an inch in diameter, in contrast to the much smaller hemispherical more distinctly raised, melanose markings. The spots vary in color from merely a slight discoloration of the leaf tissues or a condition of transluscence in young leaves, through yellow and various shades of brown to a very deep brown or black in old leaves. They are generally somewhat raised. In the younger stages there is a greasy appearance suggesting the name.

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* Fawcett, H. S. Citrus diseases of California compared with those of Florida. Cal. Agri. Ex. Sta. Bull. 262, p. 175.

Trees of all ages and in all conditions of health and disease are subject, and although no fungi have been found connected with it, indications point rather decidedly toward a parasitic origin. Except under very unusual conditions affected leaves fall, but little if any sooner than normal leaves. Because of this no attempts at control are considered necessary.

ANTHRACNOSE, WITHERTIP (*Colletotrichum gloeosporioides*).

This fungus is commonly credited with being the cause of heavy loss in citrus. It is true that it is of universal occurrence on dead and dying twigs and in leaf and fruit spots. In fact, citrus leaves and twigs from apparently normal trees almost invariably develop the fungus when sterilized externally and placed in damp chambers. In spite of its prevalence, however, there is a growing opinion that it is more of the nature of a saprophyte or a weak wound parasite than a virulent parasite as so often considered.

Very typical anthracnose spots occur on the fruit. These are medium to dark brown, somewhat sunken with a definite margin and may occur on any part of the fruit. The relation of the fungus to fruit rot is considered in more detail later. Fruit on trees weakened by other diseases or faulty environment will be most generally attacked. Spots on the fruit of normal trees are generally due to some other initial cause. The staining of the fruit, or the rough brown russeting, known as tear-staining, caused by surface growth of spores washed down from dead twigs above, is common in Porto Rico.

On the leaves the spots are irregular to rounded, brown at first, then dull gray, zoned because of the arrangement of *sporodochia* (conidia-bearing bodies) in concentric lines. Probably for the most part confined to leaves of weak trees or to leaves injured by insects or other fungi.

On lemon seedlings a leaf disease, acting with scab at times, caused practical defoliation. The spots were brown, irregular, rapidly involving most of the leaf, coalescing if several, not zoned. The fungus resembles *C. gloeosporioides*, but may prove to be distinct when further studies are made of it.

As noted, *C. gloeosporioides* is exceedingly common on dead twigs, but it is rather easy to trace the death in most cases to some other initial cause, such as *Diplodia* or any of the other diseases such as pink disease, psorosis, foot rot, root rot, etc., which weaken the tree or produce dead wood in the tops on which the *Colletotrichum* can then readily grow. Unfavorable growing conditions produce the same result.

Pruning while advisable can hardly be of any permanent value unless additional measures are taken to control other diseases present as primary causes or to remedy faulty cultural conditions. In a word, the presence of *Colletotrichum* is rather an indication of some deeper lying trouble, the correction of which will *per se* eliminate the anthracnose or withertip.

FRUIT ROTS.

There has been continued heavy loss in oranges and grapefruit from the various fruit rots. Blue mold (*Penicillium* sp.) and stem-end rot (*Diplodia natalensis*) as in previous years have been the causative organisms for the most part. The anthracnose fungus, *Colletotrichum gloeosporioides*, played a minor part as did certain other fungi, *Aspergillus flavus, A. niger, Mucor* sp., etc. In addition, about the usual amount of the orange crop was lost by blossom end rot due to *Alternaria citri* and *Fusarium* sp. Beyond additional isolations no further studies of these two latter fungi were made, time not permitting.

Certain natural conditions have contributed to the loss in addition to those that are always operative, such as the lack of care in handling and shipping, poor grove practice, etc. In August a severe windstorm not only knocked off some fruit, but seriously injured a much greater amount through wounds and bruises from thorns or twigs. This permitted various fungi to gain ready entrance and undoubtedly accounted in part for the heavy losses sustained during the early part of the shipping season. A long-continued period of wet weather in December also added to losses through this channel, and the situation was still further complicated by the attempt on the part of the growers to hold over what fruit was not shipped during the fore part of the season until March or later. At this time the bulk of the fruit remaining was over-mature, a stage in which it is most susceptible to stem-end rot.

In the course of the work on fruit rots a very large number of cultures were made which revealed the usual fungi for the most part. One interesting case occurred, in which an isolation from a rotted grapefruit yielded *Schizophyllum commune* in pure culture. This fungus is most common, acting as a wound parasite of cane to some extent, but for the most part merely a dead-wood form. Innoculations into healthy fruit produced a soft rot with the peculiar pungent odor noted in the original rotted fruit.

Of one lot of grapefruit brought to the laboratory in sacks, which permitted rough handling, sixty-four out of three hundred and ten,

or 20 per cent, were rotted by *Penicillium* and *Diplodia* in about equal proportions when examined four days after picking. This was in March. A large portion of the fruit remaining broke down before it could be tested by the chemist.

All rotted fruit from lots brought in for testing by the chemist were examined and in a majority of cases cultures were made to ascertain definitely the cause. One box of one hundred and thirty grapefruit was divided into thirteen lots, and one tested each week between October 25 and January 29. This fruit was carefully handled. Each lot developed from one to eight rots, thirty in all, and all due to *Diplodia* except one, the culture of which gave *Colletotrichum*.

The triumph variety matures early and is very subject to rot. To secure data on the cause and nature of this rot a box of sixty fruit of this variety carefully handled was brought to the laboratory October 25 and spread out on a table. Those showing signs of rot were cultured. By January 12 thirty-three had been so tested, twenty-four showing *Diplodia*, eight *Colletotrichum*, and one *Fusarium*. *Aspergillus* spp. were present as secondary agents of decay in several instances.

At the time this fruit was brought in a number were marked by irregular areas very light red or pink in color. This was apparently due to a surface attack by *Colletotrichum*. The spots seldom increased in size and rot did not follow; an affected fruit drying up unless attacked by stem-end rot.

A series of oranges, 108 in number, was brought in at the same time and treated in the same manner. Between that date and December 10 the majority were destroyed by a typical soft rot induced by *Diplodia*, in many instances with *Penicillium* (blue mold) as a secondary agent. Twenty-eight were diseased by *Colletotrichum*, in most cases confined to spots on the side or shoulder, the fruit drying up. Seven remained sound and the remaining five were rotted by *Aspergillus* and *Fusarium*.

In addition to these, several series of miscellaneous oranges and grapefruit from various sources were cultured from time to time during the year. Forty such cultures were made. Grapefruit brought in soon after the storm of August were bruised on the sides, and from these spots *Diplodia* was obtained in the cultures. Typical cases of stem-end rot invariably yielded this fungus, brown anthracnose spots were due to *Colletotrichum*, and such blossom-end rot as occurred was due chiefly to *Fusarium* sp. Cultures obtained from grapefruit were *Diplodia* 6, *Colletotrichum* 3; from orange, *Diplo-*

dia 9, *Colletotrichum* 7, *Fusarium* 6, *Aspergillus* 1, and *Penicillium* 1, sterile or overrun by bacteria 7.

Measures to check the heavy loss from the various fruit rots (as high as 75 per cent of some shipments) are available to all who will but use them. These consist of care in picking, packing and shipping, all considered in detail in several publications readily obtainable and of the proper pruning of the trees and the disposal of all dead wood and rotted fruit from beneath them. Spraying will be of little value.

SPLITS.

The navel orange, a variety which is almost a complete failure in Porto Rico, is especially subject to this trouble. The cause is somewhat uncertain, but is generally considered to be due to unequal growth, that of the rind not keeping pace with that of the internal portions. Heavy rains following drouth are especially apt to bring it on.

BUCKSKIN.

Buckskin is a disease of the epiderm or skin of the fruit only. The outer layer of cells is killed, taking on a characteristic gray or silvery gray scaly appearance. A buck-skinned fruit of whatever size ceases to grow and is generally valueless because of thick skin and lack of juice. The light color of the deadened tissues and the fact that it is readily removable distinguishes this form of injury from that due to mites or withertip russeting. The amount of buckskin present varies greatly from year to year, may be very abundant one year and entirely lacking the next. In some cases spraying with bordeaux has apparently increased the amount, and in others has been reported as preventing. It is more common on the lower branches and in the center of a tree. The cause, variously attributed to a surface-growing fungus or to an alternation of periods of drouth and heavy rainfall, is obscure.

SILVER SCURF.

This is a type of injury somewhat resembling the above but lighter in color and limited to small areas of the fruit only. It is sometimes due to spray injury, or more often to thrips or other injuries occurring when the fruit is young. Of no importance.

SMOKY FUNGUS (*Leptothyrium* sp.?).

Spots probably due to a fungus of this nature occur to some extent. They are black, irregular and form a very light coating only

on the surface of the fruit. The fungus growth was confined for the most part to the regions between the oil cells, dimming the color of the fruit and giving rise to the name of smoky-fungus. The spots are readily removed by the brushes in the packing house. Lime-sulphur as applied for rust mite will doubtless eliminate it. No spore form was found.

GUMMING AND DROPPING OF FRUIT.

It is a most common occurrence for a certain portion of the grapefruit to drop when they are from an inch to an inch and a half in diameter. The per cent of such dropping varies from season to season and from grove to grove. During the present season following the second bloom as high as fifty per cent or more of the fruit was lost in this manner. The fruit which drop are prematurely yellow and generally marked by irregular, brown, gum infiltrated spots of varying size. The white pith tissues at either end are brown stained for a short distance. In the early stages no fungus has been found. *Coletotrichum* attacks all fallen fruit, but is not the cause of the dropping.

It is believed that the cause is a natural one, the setting of more fruit than the tree can take care of. Any reason such as the prolonged drouth of the early part of the season, the scarcity of fertilizer, presence of disease, etc., tending to weaken the trees would help to bring about this dropping.

ALGAL LEAF SPOT (*Cephaleuros mycoidea*).

This leaf spot, due to a parasitic alga, is exceedingly common on the lime, so much so that it would almost serve to identify the species. On the other citrus species—grapefruit, sweet and sour orange, lemon, and kumquat—it is of limited occurrence. The same form has been collected on a wide range of other evergreen-leaved hosts, such as *Ficus* spp., *Nectandra* spp., *Artocarpus integrifolia*, *Hibiscus* spp., etc. No appreciable damage results beyond the hastening of the dropping of old leaves.

The spots are nearly circular, up to one-fourth inch in diameter, slightly raised, reddish at first, but soon turning brown, and finally very dark brown. At the fruiting stage short, erect, reddish hair-like processes are to be seen bearing the reproductive bodies at the tips. By some this disease has been confused with canker, from which it differs most clearly in that each spot is confined to one side of the leaf only.

A related species of the same group, or possibly the same as noted above, has been collected on grapefruit and gandul (*Cajanus indicus*), where it produced irregular, often confluent, areas on trunks and branches. These often extended for considerable distances up and down the part attacked, and were characterized by a red velvety layer, the fruiting portion of the parasite.

These two types have not as yet been found occurring together in the same tree and but rarely in the same grove. No special corrective measures are necessary. The removal of dead or over-mature gandul plants would doubtless help in checking the latter type at least, a procedure recommended for other more important reasons.

FRENCHING, MOTTLED LEAF.

A condition of chlorosis or yellowing of the leaves commonly called frenching or mottled leaf is a symptom of disease and not a disease in itself. The causes are in many cases obscure or even entirely unknown. Yellowing follows, or is a symptom of various diseases such as the root disease, blight, etc., and also results when trees are growing under unfavorable circumstances such as standing water, poor soil, etc. The presence of injurious chemical substances, the lack of certain fertilizing elements or an over abundance of ammonia have been considered as causes of serious chlorotic conditions. Nematode worms have been blamed for one type of yellowing in California. They have not been found in Porto Rico.

Various types of yellowing or chlorosis occur throughout the citrus regions. The so-called yellow spotting has not been seen in Porto Rico. A more or less uniform yellowing of the leaves is common and traceable in most instances to some one of the causes detailed above. The most usual type of yellowing yields readily to the fertilization given after the crop is removed.

The form usually known as frenching is rare, having been found on only an occasional tree. The yellowing in this disease is not uniform over the leaf, but consists of irregular patches between the main veins, which remain green. The cause is not known, although the various theories of nematodes, injurious chemical substances in the soil, over-ammoniation, etc., have been put forward.

SOOTY MOLD.

This very common fungus does not cause a disease, but lives on the secretions (the so-called honey-dew) of certain of the injurious insects, the hemispherical scale, turtle-back or black scale, the wooly

white fly, etc. No damage is caused except by the cutting off of the light from the food manufacturing tissues of the tree by the black sooty layers formed over fruit, leaves, and twigs. A variety of spore forms are produced, but whether all are of one species or several has not been definitely worked out. It is not of sufficient importance to warrant detailed studies.

Sooty mold can be eliminated by killing the scale or other insects by the use of oil emulsion sprays, which are most efficient. The absence of the scale and the accompanying black mold will do away with the necessity of washing the fruit in tanks or by hand, a procedure which paves the way for rot.

MINOR LEAF DISEASES.

A leaf spot apparently due to *Phyllosticta* sp. has been noted in a number of localities, generally on isolated trees only and often confined to a majority of leaves on one branch. The areas are irregular and vary considerable in number from one to many. They appear to commence on either surface of the leaf, but soon grow through to the other. They are marked by definite, medium brown margins, with gray centers in which appear the minute, scattered, black pycnidia. In the early stages the spots are brown and slightly raised (plateau-like). The spots are at times confused with those due to *Colletotrichum*, or the latter may follow the *Phyllosticta*, which is strictly parasitic.

Another very distinct type of leaf-spot due to an unknown cause has been observed in one very large grove of newly planted grapefruit trees. Older leaves only were subject to spotting. The spots were numerous, irregular to nearly circular, up to seven or eight millimeters in diameter, slightly raised with very definite red-brown margins, and centers brown to dull tan.

A peculiar condition of terminal leaf clusters has been observed in grapefruit nursery trees, in which all the leaves were distorted, stunted and one surface (generally the back) glazed. No cause was found. It is possible that drouth may have been an underlying factor.

Leaf lichens (*Strigula* sp.) producing silver spots, liverworts, etc., grow on the leaves of citrus in damp situations as epiphytes without doing any harm, beyond possibly cutting off a part of the light.

CANE DISEASES.

INTRODUCTION.

There has been heavy loss from cane diseases in the season just closed. This has not been due to the introduction of any new and strange diseases, or to any sudden assumption of virulence on the part of those fungi already occurring on the Island, but rather has been the result of an accumulation of disease due to a favorable combination of climatic and cultural conditions. This trouble, which in the minds of many has assumed the proportions of a serious epidemic, has occurred for the most part in that part of the Island extending from the vicinity of Cambalache (Arecibo) to Aguadilla, a region which is comparatively dry. The fields subject to attack have been for the most part those of the smaller owners or "colonos."

An attempt was made on all field trips to explain the nature of the trouble, and the remedies therefore to as many of the planters and their "mayordomos" as was possible. In addition, reports were prepared on each trip which gave definitely and in some detail the measures recommended in each case, and these have had wide distribution through the medium of the Island newspapers and the sugar companies operating in the infected districts.

CAUSES.

Briefly stated, the trouble is due to an accumulation of various diseases, including disease of the rind and some root disease directly induced by unfavorable weather conditions and poor cultivation taking the last term in a broad sense. While the Arecibo-Aguadilla district is quite subject to periods of drouth, it was during the months of February, March, and part of April of this year (1916) visited with a more than unusually long and severe dry spell. During a period of nearly eight weeks practically no rain fell, a state of affairs quite sufficient in itself to cause great loss. This was preceded in November and December by excessive rains, so that the cane has labored under, first an excess, and then an almost entire lack of water, conditions which would seriously injure the most resistant of crops;

and cane cannot be considered a resistant crop where the water supply is concerned.

To offset these natural harmful agencies there have not been taken in those cases where trouble has ensued even the ordinary cultural steps considered necessary to produce a good crop of cane. On the one hand the price of fertilizer is such as to put its use beyond the reach of many, or to limit its use to such quantities as are without effect in promoting better growth. On the other hand, the very high price of sugar has caused great efforts to be made to get all the land possible planted to cane, resulting in a great extension of the area and making impossible any of that intensive care so necessary for proper and successful agriculture on the heavy long-tilled soils of Porto Rico. In short, the land has not been properly prepared. There has often been but one plowing of heavy grass land followed by immediate planting, whereas several plowings with sufficient intervals between for the rotting of the sod are obviously necessary. In one instance observed the field had not been plowed even once, the cane having been planted in shallow holes scraped out of the very hard soil. The lower ends of the seed pieces rested against soil so hard that it could only with difficulty be loosened with a knife. These extensive planting methods have prevented proper attention to weeding and cultivation through shortage of labor and lack of sufficient work animals. There has, moreover, been very little if any attempt at seed selection.

NATURE OF THE TROUBLE.

The presence of the trouble wherever observed has been most readily apparent. Even from a distance seriously affected fields were easily noted because of the stunted appearance of the field in general, the poor color of the leaves, and the presence of blank spots where stools had died out completely. Upon close examination the stalks were found to be small, with the joints close together, and the internodal areas discolored or more or less completely covered with deadened irregular areas, sometimes not extending deeply into the tissue, but at other times forming deep cankers. The leaves of advanced cases were in large part brown and dead, and the few remaining alive much more narrow than is normal, and of a peculiar mottled appearance, a light dull green, closely interspersed with irregular chlorotic (yellowish or white) spots and stripes. The lower leaf sheaths were commonly cemented together by the white mycelial growth of one or more of the fungi connected with root disease. In

many cases on the outer sheaths, and from the ground up to a height of eight to ten inches, the white powdery fructification of *Odontia* sp. occurred. This form is so commonly found in connection with cases of root disease that detailed studies of its parasitism and its possible connection with other fungus growth found in and about the base of cane stalks and roots must be instigated.

The feeding roots were invariably dead to a large extent, and in advanced cases the entire mass of rhizome and roots (the underground portions of the cane stool) was dry-rotted and permeated by the white mycelium of what is now known as the stellate crystal fungus (*Himantia stellifera*). Because of the fact that these observations were carried on during dry weather fruiting bodies, with the exception of those of *Odontia*, were not observed in connection with the root disease, and hence it cannot be definitely stated what other fungi are concerned. It may be stated, however, that in all specimens examined stellate crystals were found on the hyphal threads, and that no certain trace of *Marasmius sacchari* was found.

Investigations of the fungi concerned in the stem cankers are in progress and a detailed report will be made later. *Colletotrichum falcatum* (the red-rot fungus) and *Melanconium sacchari* (the rind disease fungus) have been found in this connection. Other fungi were present on dead stalks, in particular *Diplodia cacaoicola, Schizophyllum commune, Nectria* sp., and *Trichoderma lignorum*, but only as saprophytes or secondary agents of decay. Doubtless many others of this class could be found in a more favorable season.

The external symptoms, then, were the general dwarfing of the stools with their complete destruction in isolated cases, or in irregular areas; a narrowing and mottling or frenching of the upper leaves, discoloration and dying of the stalk between the shortened nodes, rotting and binding of the leaf sheaths by fungus growth, and a dry rotting of the underground portion of the stools. Internally there was for the most part merely a drying and shrinking of the tissues due to dry-rot. Only a very few cases of typical internal red rot were found.

VARIETIES ATTACKED.

In the Arecibo district the common white cane (Otaheite), locally known as "blanca," has been the most subject to this trouble. The amount of damage to this variety has been very high, certain large fields having been almost a total loss, since even the small tonnage produced was refused by the centrals because of its low sugar content, and the difficulty of elaboration due to high glucose content.

Tests conducted by the chemist at Central Cambalache with cane of this kind showed a very high and objectionable glucose content with corresponding low sucrose. While this white cane has not been universally subject to disease, since some fields of it were found which were reported to give good yields with satisfactory purity, yet on the whole the variety is weak and shows decided tendencies to what is popularly known as "running out." This point will be more fully considered in the discussions to follow.

A second variety, a red cane, known as "cavengerie" and at times locally as "rayada colorada" or simply "rayada," was likewise apparently as susceptible as the white cane, although the plantings of it were by no means so extensive. Growing intermingled with it there was often a darker red type, the so-called "rayada morada" or "sarangola," which was introduced to replace inferior varieties during a similar epidemic of trouble on the cane plantations in the nineties of the last century. As far as observed it was markedly resistant; not a lesion to be found on the stalk; and of the fungus around the base no more than occurs normally in the average cane field of the Island. One case was found where all three types were growing in the same stool, two typically diseased, the third (*rayada morada*) healthy and vigorous.

So it becomes clear that yet a third point in addition to the weather and lack of cultivation enters into the situation, an apparent degeneration or "running out" of a variety or varieties. A similar case may be cited from the British West Indies. This same white cane or a type very similar and known as "Bourbon" or "Otaheite" was for many years the only cane raised in Barbados and other of the British West Indies, and formed the basis of a flourishing sugar industry. In the year 1895 the cane was suddenly attacked by a virulent type of rind disease, which within a short time had spread to such an extent that the sugar industry was threatened with extinction. The situation was saved by the growing of new varieties, some brought in from other parts of the world and others (among these some of the best) produced by the Barbados Department of Agriculture as seedlings. Non-susceptible or resistant varieties were substituted for the non-resistant and the destruction of the principal resource of the several islands prevented.

A parallel situation seems to have arisen on this Island at about the same time and with the same variety. In this case seedling varieties were out of the question and importation of foreign canes was the only solution, resulting in the introduction of the "sarangola" and possibly other types of cane. Notwithstanding the exist-

ence of these improved canes, the growing of the Otaheite has persisted in spite of its weaknesses, party because of its excellent milling qualities and high yields under favorable conditions, and partly because of disinclination to change to anything new. That there has been constant trouble with it because of the ease with which it succumbed to disease is apparent from the first report of this station, where Mr. Crawley, then Director, writes as follows:

"The white was formerly the principal cane planted not only in Porto Rico and Cuba, but in the adjacent islands; but it has succumbed in the British West Indies to diseases, and has been superseded chiefly by hardier seedlings. What has happened in those islands is happening in Porto Rico. The root disease is affecting the cane very badly, and it ratoons poorly, particularly in the older and poorer land. I consider the introducing of hardier canes to be of the greatest necessity in Porto Rico."

Many of the larger land owners and the central companies, insofar as they controlled the land from which their cane came, substituted improved varieties, Cristalina, Rayada, foreign seedlings, etc., for the white or Otaheite, but as noted above others and in particular the smaller land owners and planters have most persistently clung to the old favorite.

CONTROL.

The situation, while it has been most serious for those concerned and conducive of much financial loss is by no means so hopeless as has been thought. It cannot be called an epidemic of disease in the sense in which that word is commonly used, since there is by no means any new or virulent parasite present which is sweeping to destruction all cane in its path, but rather old, well-known enemies which favored by a combination of untoward circumstances have joined to cause trouble. Similar situations have arisen before and have been checked by means which are now at hand and even to a greater extent than on those other occasions. These control measures may be considered under a number of heads. No one of these will suffice, but rather a judicial combination of all applied as the circumstances and peculiar conditions of each planter permit.

It is more than likely that the discussion to follow is not entirely in accord with theoretical disease prevention, but an endeavor has been made to adapt the recommendations to Porto Rican conditions as they exist to-day rather than to present an ideal and hence impractical scheme which no one would follow.

As has already been noted, lack of this essential necessity has been one of the chief causes of trouble, and may be expected to continue to play a leading part unless a radical change of methods can be brought about. One plowing of any piece of land, and especially of pasture lands, the type so commonly turned to cane cannot by any stretch of imagination be considered sufficient. It is hard to see how less than two and better three can be taken as a minimum with a thorough harrowing after each. The interval between the first and second should, of course, be sufficient to allow the sod and vegetable matter of the former crop or of the pasture to thoroughly decay. The importance of this can be better realized when it is recalled that the root disease fungi (at least *Marasmius sacchari* and the stellate crystal form) occur in greater or less abundance on a large number of the common pasture grasses and even on some of the common weeds. Hence time must be given for the rotting of the vegetable matter upon which they live so that they may be reduced to a minimum before the cane is planted. The more often the plowing and harrowing with the consequent turning of the fungus material in the soil up to the light and air, the quicker decay results and the less infection that will occur on the crop that follows. Exposure to sunlight and air has a most deleterious action on these fungi.

There is no need of going further into the benefits to be derived from a thorough preparation of the soil. They are well understood by every agriculturist. It might be well to add, however, that an effort should be made to avoid plowing year after year at the same depth, a practice that results in the formation of a hard layer of soil through which the cane roots cannot penetrate. Rain instead of entering freely runs off on the surface, carrying the best of the soil with it and the cane roots confined to a relatively thin layer of top soil suffer during any time of drought.

FERTILIZING AND LIMING.

Fertilizing beyond aiding in the production of strong healthy cane has no direct influence in so far as known on the amount of disease present. It is entirely a matter in which the planter must choose his own course.

There are few soils in Porto Rico which would not be benefited by the addition of lime and in large amounts. Liming would have little if any direct influence in checking disease, but is most valuable

in improving the physical properties of the soil, in making available the mineral food materials, and so giving increased yields. In as much as no two soils are alike in chemical and physical properties, it is quite out of the question to say offhand which soils should be limed and which not. It is again a point with which each planter must experiment for himself. There can be but few instances, however, where heavy applications of lime (one to two tons per acre) in whatever form is desired, or is cheapest, will not prove of value provided it is not considered as a cure-all, and no further endeavors made to control the situation.

VARIETIES.

In the present case the substitution of new and improved types for those that have shown themselves undesirable is of great importance. While it is true that the white cane in certain localities under favorable conditions, and even in some fields in the district in question is giving satisfactory yields, yet as a whole it is most apparent that it is undesirable and accordingly should be discarded. The same applies to the "caña de vino" or any other variety which fails to come up to standard.

With the present wide range of varieties obtainable from this Station * and other sources, some of which at least are beyond any reasonable doubt satisfactory, there can be little excuse for attempting to continue with a type so decidedly inferior. It should not only be possible to obtain a type which will equal the white at its best, but one that will prove superior in all respects that go to make up a good cane, tonnage, purity, sucrose, etc. As to just what particular kind will serve is uncertain until trial has been made under the particular soil and climatical conditions of each region or locality, one will prove superior in one locality and another in another, certain ones prove best in dry situations, others in wet lands, etc. It is desirable that the planter experiment with several until one is found which meets his conditions.

To solve the problem by merely changing from one variety to another may appear so easy for some that such other conditions as are given here for successful cane culture in the face of present difficulties will be neglected and a word of caution is necessary. No matter how vigorous and apparently disease-resistant a given variety may be at this time, the question of how long it will be able to so maintain itself in the face of poor growing conditions is another

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* Circular No. 8, "Distribución de Caña para Semilla."

matter. It must be realized that the various diseases are always present in and about the fields, awaiting the time as it were when poor cultivation, drouth or other circumstances have reduced the resistance of the cane to the point where they may attack. It is decidedly up to the planter to see that conditions in so far as they lie in his power are made favorable for the cane and not the fungi.

SEED SELECTION.

The appearance of disease-free fields in close proximity to those seriously attacked or even entirely ruined can be explained in large part by proper seed selection on the part of the planter. Several fields were noted in good health and the owners stated that clean seed (of the white variety) had been brought in from other localities for the planting. In some of these cases good cultivation was doubtless approximated explaining the difference in part, but in part only. One case in particular was observed of a field of plant cane, the seed for which was secured in another locality, that was in as bad shape as any field seen on the trip. The planting of the seed (reported to have been select tops, disease-free) had been in disease saturated, poorly prepared soil. Clean seed alone then cannot be depended upon to control the situation.

There has been such a demand for seed due to the universal increase in planting that little regard has been given to the quality. There can be little doubt but that in some instances cane, in such condition because of disease that it was refused by the central, was used for planting in blind disregard of the consequence. As a preliminary test of seed of this nature average portions of the diseased canes were brought in and planted in trial plots at this Station. As would be expected very poor germination was secured and such shoots as did appear have grown slowly, and are marked by narrow leaves with the characteristic markings observed in the fields.

It cannot be too strongly pointed out that the selection of clean, healthy seed is essential. The necessity of using top seed free from any internal discolorations indicative of disease, particularly red streaks, should be apparent to all. The use of top seed of course in itself eliminates the danger of planting material already infected by root disease, since these forms rarely reach a height of over a foot or two, at best, above the ground level, but care must be taken to avoid stalk diseases.

A further point in selection is the matter of securing seed from other districts, or at least from fields free of disease. While seed

from a distance has nothing in particular to recommend it in so far as coming from away is concerned, often the contrary, yet such a course is the only practical one in the present instance for securing the necessary quality of seed. . The use of tops from apparently disease-free stalks of stools in which the remainder are diseased, or even from clean stools where all or large portions of the field are seriously diseased, is to be strictly avoided. It will be found that material of this sort either already contains fungus or is of such a weak type that it readily succumbs. Laboratory tests in instances of this kind are reported to have shown the presence of the rind-disease in all stalks of a stool, even if some are, to all appearances, normal.

TREATMENT OF SEED.

The practice of dipping the seed cane in Bordeaux mixture before planting has much to recommend it. An opportunity is given for careful inspection and consequent rejection of all poor seed pieces and perfect protection is given against the pineapple disease or black rot of cuttings. Such treatment, however, cannot be of the slightest value in disease prevention if the seed pieces are already infected internally, as so much of the seed now appears to be. Nor can such treatment avail to protect the roots and young shoots from attack by root disease and other troubles. The action of the Bordeaux is limited to giving protection to the cut ends of each seed piece from those soil dwelling fungi which attack through these openings and which under proper conditions destroy the seed before the young stool has established itself. As far as it has been possible to learn the situation the pineapple disease gives little trouble in the comparatively dry sections of the Island under consideration.

Some experiments of scientists in other countries have demonstrated that dipping does not give a large enough increased yield to pay the additional expense. Eperiments conducted at this Station indicate that the practice is advisable in humid sections where heavy losses have been sustained from the black rot. It is not believed that dipping will aid to any appreciable extent in checking the present trouble, certainly not to an extent sufficient to pay for the added expense. Dipping would be advisable if a long wet spell should ensue.

CULTIVATION.

Keeping down the weeds and conservation of soil moisture during periods of drouth are the important factors in this connection. A heavy growth of weeds is supposed to favor fungus growth in

and about the base of the cane by creating moist shaded conditions, but this is more of a theoretical consideration than a practical one. The water and raw food materials taken up by them are matters of more importance (especially in the district under consideration) than any influence the weeds may have in the first instance. Cane growing from healthy seed, under conditions as nearly normal as can be provided, would grow through weeds oblivious to the fungi provided there was a sufficient supply of water for both cane and weeds. The most healthy cane, on the other hand, would suffer, weeds or no weeds, when the water supply was insufficient. Cultivation then, serves to maintain the moisture supply of the soil by preventing evaporation from the surface or its use by plants other than the crop plants.

TRASHING.

From a strictly theoretical viewpoint removal of dead or dying stools, and in particular of diseased leaf sheaths from about the base of the stalks, would be of assistance in control. Practically, however, but little good would be expected from such a practice. It certainly would not pay for the money expended.

As a matter of fact experiments in stripping and trashing carried on both at this Station and in other cane countries have demonstrated that this practice causes an actual falling off in yield; a result which in itself effectively condemns the practice. Still a further point is the possibility of damage to the stalks through the removal by careless workman of living green leaves. This would cause wounds and permit the entrance of the rind disease or other diseases of the stalk. In as much as the cane in this district is already very subject to such diseases, trashing would but provide one more source of infection, and a most effective one at that.

DISPOSAL OF TRASH.

It is firmly believed that the burning of trash is an undesirable practice. It is urged by many writers that such a course serves to destroy harmful fungi or to reduce the amount present below the danger line. On the contrary, it becomes more and more apparent that destruction of the trash is not only conducive of no benefit, but is actually harmful and in more ways than one. First, as studies by the entomologist of this Station have shown, it causes an increase of the moth stalk-borer by destroying their insect parasites. This point is discussed in full in circular number seven of this Station and need not be further considered here.

Second, all Porto Rican soils need humus and those of the infected section most especially. There is no need to dwell upon the value of humus, since its beneficial action on the physical properties of the soil and its aid in conservation of soil moisture are well understood. Through the exercise of these properties, humus has a decided influence on the health of the cane and the consequent amount of disease present. Destruction of the trash most effectively deprives the soil of this valuable constituent.

Third, and equally important, is the relation to the amount of disease. Burning the trash as practiced in Porto Rico is ineffective in destroying enough fungus material to be of any value in diminishing the amount of disease which will be present on the ensuing crop. The bulk of the root disease is below ground, and is therefore untouched by fire. A fire hot enough to sterilize the soil to a depth sufficient to eradicate root disease would kill all the cane roots at the same time. Above ground practically nothing is consumed but the leaves. The pieces of stalk remain, charred externally, but internally untouched, so that rind disease, red rot or other diseases pass through uninjured just as do the moth stalk-borer larvae and have merely to grow out to the surface again to be ready for dissemination to the new crop of cane.

To illustrate further the non-effectiveness of fire in controlling cane disease, we have but to mention that the various leaf diseases, such as ring spot (*Leptosphaeria sacchari*), red spot of the leaf sheath (*Ceroospora vaginae*), red rot of the leaf sheath (*Sclerotium Rolfsii*), etc., are not checked to the slightest degree by burning. If fire has no effect on fungi of the leaves which are destroyed, it is difficult to see how any results can be expected in the case of the fungi of the stalks which escape destruction.

As a result of observations made in various cane fields, it would appear that where non-burning is practiced the numerous saprophytic fungi speedily rot down the débris and that little infection can pass to neighboring healthy cane. Certainly in those places where the trash has been retained, and there are plantations where this has been the practice for years, no trouble with disease has resulted. Burning, on the other hand, destroys these fungi (beneficial since they aid in making humus), and on the stalks remaining the harmful fungi develop unchecked by the saprophytic forms which ordinarily would overrun them. Methods of properly handling the trash are well understood and need not be further elaborated here.

It must be readily apparent to all that once disease has taken possession of a field to such an extent that a satisfactory yield is not obtainable, but one thing remains, plow up the field and then use the land for some other purpose or give sufficient interval for a thorough rotting of all vegetable matter before replanting. It cannot be expected that any measure other than this will prevail where the soil is completely saturated, as it were, with disease, and the cane stools themselves impregnated with rot. Healthy cane shoots cannot arise from diseased roots.

The practice of attempting to ratoon year after year, replanting the spots where the stools die out from disease, has been conducive of much loss and cannot be too strongly condemned. This invariably results in a great accumulation of disease, reaching in time a point where it is impossible to secure a crop at all. As has been noted, it is not practicable under present conditions to remove disease-killed stools, and replanting in such places can be but a waste of time and money.

A modification of the continuous crop system is that of plowing once between the old rows and then planting in the furrows thus made. This avoids to some extent infection of the seed from the old stools. While, of course, this permits of a great saving in the expense of crop production, it is decidedly objectionable from the disease standpoint and should not be practiced where trouble is being experienced.

It is interesting to note in connection with the question of ratoons that in some important cane regions, Java, India, and others, that plant cane only is grown and that as soon as the crop is harvested all the roots, trash, etc., are removed. Other crops are then planted for one or two years. Root diseases, it is needless to say, are of little importance there. While such a system is quite out of the question for Porto Rico now, it is to be hoped that satisfactory rotations will be worked out, so that one of the chief reasons for the accumulation of disease (continuous growth of cane) will be eliminated.

DRAINAGE AND IRRIGATION.

Cane is a shallow-rooted crop, which suffers from either an excess of or lack of water. Either extreme weakens the plants by killing large numbers of the fibrous roots and so permits the various fungi to obtain a foothold. Strange as it may seem, both of these practices (drainage and irrigation) are of importance in the parts of the

Island under consideration because of the unequal distribution of the rainfall. The matter of proper ditching to carry off the surplus water is so well understood by the planters in general and is so universally properly carried out that no further discussion of drainage is considered necessary.

It is not the south coast of the Island alone which stands in need of irrigation. On the contrary, there are few parts of the Island which at some time or other are not subject to drouths of sufficient severity to cause decreased yields. This is particularly true of the region from Manatí west and several of the larger companies have met the situation by the installation of extensive irrigation systems. Such a solution of the problem is, of course, only possible for large holdings since the small land-owner lacks the necessary capital to cover the initial outlay. In some instances driven wells and a system of pumps will be possible and will be found to give excellent results.

Irrigation from any source becomes difficult or practically impossible in much of the rough hill land now planted to cane, and recourse must there be had to frequent shallow cultivation to conserve what moisture the soil does contain. Those soils that have been well cultivated and contain the vegetable débris from former crops will, in the crucial time of a drouth, be much more apt to produce a crop than one that has had the usual lack of care so generally observed. Some fields near Arecibo in the past season were seen that were practically a total loss due to a combination of drouth and poor cultivation without any appreciable amount of fungus disease being present.

An even supply of water throughout the period of crop growth is then the ideal condition, toward which the grower can contribute by arranging for drainage, and for irrigation where possible, or by cultivation to prevent loss of soil moisture.

CONCLUSION.

While it is felt that the situation will yield to the application of measures here advocated, certain points have arisen during the course of the investigations with which it is proposed to carry on further studies and observations. These relate to the various fungi connected with the trouble and their interrelations. In particular, the fungi causing the lesions on the stalks and the internal rots will be studied to ascertain whether one or more forms are primarily responsible, the modes of attack, further methods of control, etc.

In the course of the work on cane diseases various fungi of minor importance have been collected. Descriptions and notes of these forms will be reserved for a supplement to the publication on "Cane Fungi," now awaiting publication.

LIGHTNING INJURY.

An interesting phenomena was observed in one of the Station fields. An area of approximately a square rod was found in which the cane had been completely killed. Only a few dead and dry stalks, broken off two or three feet above the ground level, remained. There had been no growth of new shoots and examination showed that the underground portions of the stools were likewise dead. There was a growth of weeds present, but entirely of herbaceous annuals, which could have been seeded from the margin of the area or carried in by wind. No signs of injurious insects, rodents, or fungi were found, not even of the non-harmful types which attack dead or dying canes. The surrounding cane was likewise entirely free of insects or fungus diseases and was growing vigorously. Charred bits of cane trash were finally discovered, which fact, combined with the other observations, indicated that lightning was the cause. No other source of fire could have destroyed green cane so completely, especially the underground portions of the stools. Such occurrences are apparently rare.

MINOR DISEASES AND NOTES.

ROOT-KNOT (*Heterodera radicicola*).

These minute worms have been found attacking very seriously the variegated coleus (*Coleus* spp.), an ornamental Passiflora (*Passiflora* sp.), all varieties of Begonias, and several of the native weeds (*Alternanthera sessilis, Phaseolus adenanthus*), in addition to a number of the common vegetables. Doubtless many other hosts will be added to the list as the investigations are continued. Both formalin and sulphuric acid in varying strengths were used for treating infested beds after all diseased plants had been removed, but without success. Care must be exercised to avoid infested soil, if it is not possible to treat it with steam or fire or to use non-susceptible plants.

TRUNK ROT OF LAUREL DE INDIA.

A magnificent specimen of this species (*Ficus nitida*) was noted in which exposed roots and a section of the trunk on one side to a height of eight feet had been killed by a fungus, known technically as *Nummularia Bulliardii*. This fungus is of very common occurrence on fence posts and dead wood in general, and this is the first instance in which it has been noted as a wound parasite, although it has been reported as such from others of the West India Islands. In the present instance the diseased portions of the tree were covered with the characteristic flat crust-like fruiting bodies. These were of varying size, several inches across as a rule, red brown to black and pitted with small openings at regular intervals, which were the mouths of the flask shaped receptacles bearing the spores. The removal of all rotted wood and fungus material was recommended to be followed by painting of the wound.

VIOLET LEAF SPOT (*Cercospora violae*).

The cultivated violet, much used as a border plant, has been commonly and at time seriously attacked by this leaf spot. The areas were numerous, irregular to rounded, up to four or five millimeters in diameter, gray with brown margins, and of the same appearance on both sides of the leaves.

ZINNIA LEAF SPOT (*Cercospora atricincta*).

A leaf spot has been noted on this common ornamental. The spots numerous, irregular, one to four millimeters in diameter, gray to a dirty white with a definite brown margin, appearance the same on both leaf surfaces.

ROSE LEAF SPOT (*Cercospora rosicola*).

Most of the many rose varieties grown in Porto Rico were subject to this leaf spot, which caused irregular reddish brown spots. It sometimes was serious enough to cause partial defoliation. It is probable that other fungi also produce leaf spots not at present differentiated from the above.

In addition, a canker of the stems and a gall-like formation of the same organ have been collected on this host. Determinations of the causes have not been made.

LEAF SPOT OF DATE (*Graphiola phoenicis*).

The date palms appeared to be universally subject to this dis-

ease which caused brown leaf spots. In the center of each was produced the small cup-like fruiting body from which protruded delicate hair-like processes bearing the spores. The disease is not serious, but rather unsightly.

ROOT ROT OF AVOCADO.

In some parts of the Island the avocado trees are dying as a result of a root rot due to an as yet undetermined fungus, possibly of the Nummularia group. The trees attacked are those that have been left in fields and pastures when the other woody vegetation was cleared away. This has produced unfavorable conditions for them, particularly because of the packing of the soil by the pastured animals and has so weakened them that they are falling prey to a fungus which is ordinarily only a saprophyte or a weak parasite at best. The disease works up along the main roots, progressing slowly apparently until the crown is reached. During this time there is considerable die back in the top of the diseased tree, which, however, passes unnoticed by the casual observer, or is at least not connected with root troubles. The fungus very quickly girdles the tree once the crown is reached and rapid death of the tree ensues.

It is doubtful whether any satisfactory measures can be taken to stop this disease on the trees in question. In a commercial grove it could be readily controlled by planting healthy trees, giving them proper care and eliminating any that were attacked. The fungus lives on dead wood, roots, etc., in the soil and spreads from this material to wounded tree roots. It will be evident that spraying as proposed by some can be of no avail.

ANTHRACNOSE OF MANGO, BLOOM BLIGHT (*Colletotrichum gloeosporioides*).

This omnipresent fungus, which is the cause of much disease in citrus, avocado, mango, and other fruits, is in its relation to the mango at least, apparently very subject to weather conditions. In some seasons when the bloom period corresponds with a time of heavy rainfall the crop is practically a failure due to bloom blight, and rotting and spotting of the fruit.

During the present season the blooming period coincided with a prolonged drouth, with the result that a heavy crop of fruit was produced with a minimum amount of disease. Even the leaves were comparatively free of anthracnose spots. There was the usual amount of leaf spotting due to *Pestalozzia* sp.

ENTOMOGENOUS FUNGI.

Supplementary to Bulletin 10 of this Station notes and observations upon the fungi attacking insects are here appended.

APHIS FUNGUS (*Acrostalagmus albus*).

Where not prevented by applications of bordeaux mixture this fungus has been very effective in controlling aphids (*Aphis* sp.) on several of the vegetable crops. It was collected in abundance from egg plant, cucumbers, and peppers. It produced a white to cream mealy growth covering the body of the insect and cementing it to the leaf. The determination is provisional.

CITRUS ASCHERSONIAS.

Two species have been found attacking the scale insects of citrus. *Aschersonia turbinata* and *A. cubensis*,* both on purple scale (*Lepiposaphes beckii*), the latter quite common, but the former rare. *A. cubensis* is characterized by bright red hemispherical fruiting bodies in contrast to the cup-shaped or turbinate form of *A. turbinata*.

PINK SCALE FUNGUS (*Microcera Fujikuroi*).

This form has heretofore been confused with the imperfect stage of *Sphaerostilbe cocophila*, which it closely resembles macroscopically. It was described originally from Japan and recently from Florida and has doubtless reached Porto Rico from the latter region. It apparently prefers the Florida red scale (*Chrysomphalus aonidium*) as a host, but has also been found destroying the purple scale (*Lepidosaphes beckii*) and chaff scale (*Pseudoanidia articulatus*). This is in contrast to the red-headed fungus, which is more common on the latter two scales.

This form is distinguished from the red-headed by the ring of bristles which obscures the red color of the fruiting body, giving the pink color instead and microscopically by a difference in size and shape of conidia. No perfect stage has been found. In the early stages attacked scales assume a bright scarlet color, which is most striking and helps characterize the fungus.

Too much dependence must not be put upon this fungus, or any other such form for that matter, to control scale insects in the citrus groves. Where the scale becomes at all serious recourse should be had at once to thorough applications of oil spray. The fungus will gain the upper hand in time, but much damage may and generally does result before this occurs.

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* Determination by Mr. A. T. Speare, Mycoentomologist, Bureau of Entomology, U. S. Department of Agriculture.

REPORT OF THE ENTOMOLOGIST.

[By G. N. Wolcott.]

The work of the entomological department for the last fisc has included six major lines of work: (1) the inspection of all seeds, fruits and nursery stock brought to Porto Rico, and the ment of the quarantine against noxious insects and plant from the United States and other countries; (2) the continua the white-grub investigations;* (3) the testing and popula of the paraffine oil-soap emulsion spray against the scale in citrus trees; (4) the making of observations on the abunda *Diatraea saccharalis*, the moth stalk-borer of sugar cane, in a of Porto Rico where cane is grown; (5) the continuation of th on tobacco insects and especially the flea-beetles; (6) the w out of the life histories of some of the more important ve insects and the testing and adaptation of methods of control to Rican conditions.

Early in the summer the personnel of the entomological was considerably reduced by the resignations of Mr. G. B. and Mr. Wm. C. Hanson, Jr. In December Mr. R. T. Cotto appointed Assistant Entomologist, detailed to work on tobacc vegetable insects, and in January Mr. Wm. C. Hanson, Jr made a permanent employee of the board to inspect the fumi of the cane boats coming over from Santo Domingo to Ens and to carry on field experiments on white grubs at the South Laboratory at Santa Rita.

INSPECTION AND QUARANTINE.

The inspection of the mail and express packages of plants, and nursery stock entering the port of San Juan, and of fruit plants brought by passengers arriving on the boats; the enforc of the quarantine against insects and plant diseases by the de tion of fruit brought from foreign countries; the fumigation o sery stock infested with insect pests and the return to send destruction of all citrus trees from all localities, as well as plants from the Gulf Coast States, has been carried out by v members of the staff.

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* The report on white-grub investigations will be published in the "Journal of A ture of the Board of Commissioners of Agriculture of Porto Rico."